REFLECTION INFRARED SURFACE DEFECT CORRECTION

RELATED APPLICATION

This application relies on U.S. Provisional Application Serial No. 60/076,494 filed Mar. 2, 1998, and entitled "Reflection Infrared Surface Defect Correction."

TECHNICAL FIELD OF INVENTION

This invention relates to electronic scanning of images, and more particularly to the scanning of photographic prints by reflected light and the removal of surface defects.

BACKGROUND OF THE INVENTION

FIG. **1** portrays a common art apparatus to provide reflection scanning. In this figure, a reflection original, such as a paper document or reflection photographic print **102**, is illuminated by a light source **104**. A light path **106** from the light source **104** reflects from the print **102** as ray **108**, and is focused by lens **110** onto a sensor **112**. The sensor **112** typically may be a linear silicon sensor array such that, when focused by lens **110**, it senses at any single time a line of points defining the scanning line **114** on the print **102**. As time progresses, the print **102** is moved in direction **116** so that all points on the print **102** sequentially pass under the scanning line **114** and are sensed by the sensor **112**.

The sensor **112** is attached by cable **120** to a computer **122**. Associated with the sensor **112** are support electronics **124** that convert the analog signal from the sensor **112** into scan data which are digital numbers fed to the computer **122**. Inside the computer **122** the scan data representing the image **130** is stored as a memory array consisting of an array of individual numbers **132** called pixels.

Typically, the sensor array **112** contains three lines, each line behind a filter of a different color, to scan three images simultaneously and produce multiple channels **133**, **134**, and **136** of the image, each representing a different primary color.

Also apparent in the scanned image **130** are defects such as dust, fingerprints, and scratches **138**. These defects produce minor functional degradation in scanned images of documents; however, as reflection scanners are used more and more for scanning photographic images, these defects are emerging as a major limitation on the use of reflection scanners for this latter purpose. There are several reasons for these limitations. First, unlike a document which is primarily white or black and therefore requires only distinction between white and black, photographic images include all shades, and so even minor defects degrade the distinction between shades. Second, photographic images are very often much smaller than documents, typically five inches along each side, and therefore are very often magnified after being scanned. This magnification greatly increases the size and noticeability of defects. And thirdly, photographic images are often considered aesthetic works of art which are functionally degraded by small defects that would be ignored in a document scanned only for content.

Although a professional photographer might exercise more care for images and take special care when scanning them, the image literacy revolution is moving scanners into the hands of the general public and into publicly accessible kiosks, small office environments, homes, and schools. These environments are particularly prone to defective scans because the prints to be scanned are handled by people who are not professional image handlers. Accordingly, it is

apparent that the automatic elimination of defects in a reflection scanned image would provide a major advance to the art and permit the image literacy revolution to move forward expeditiously.

FIG. **2** portrays a transmission scanning device **200** for inputting images from a transmissive media such as a negative film, or a positive film, sometimes generally called a transparency. A lamp **202** emits light ray **204** which transilluminates a film **206** and is received by a digital imaging device **208**. The digital imaging device **208** may consist of a lens and linear sensor array as previously shown in FIG. **1**, although many other configurations are commonly known in the art.

The digital imaging device **208** samples the brightness of the image at discrete points called pixels, turns each of these analog brightness measurements into digital numbers, and passes this data along cable **210** to computer **212**. Inside computer **212** the image **214** is stored as a memory array **220** consisting of individual pixels **222**.

The apparatus **200** may also include a filter wheel **226** containing several filters to color the light ray **204**. For example, a specific filter **230** may color the light **204** red, and therefore provide a scan through camera **208** of the cyan dye in the film **206**. Other filters can be used to capture images **230** and **232** in the other primary colors to give together a full color image. Other methods of distinguishing color are commonly known in the art.

Apparent in memory array **220** are dust, fingerprints, and scratches **236**. In the past, these defects were a major problem for the industry. For publication images, some major magazines were able to seal the negatives in oil between glass to eliminate most of these defects, but such a solution is obviously not appropriate for the general public. Software designers have also attempted to solve the problem by selective softening, usually with extensive user intervention. As a result, most people working professionally with images have spent tedious hours manually removing these surface defects from images.

An advance in surface defect correction is taught in U.S. Pat. No. 5,266,805 issued to the present inventor. The theoretical motivation behind this prior art method is shown graphically in FIG. **3**. In FIG. **3**, the horizontal axis represents color arranged by wavelength, and the vertical axis represents brightness measured by transmission in a transmission scan or reflectance in a reflective scan. In this application brightness is referred to by the variable "x". The graph shows the brightness of the cyan, magenta, and yellow dyes used in photographic color images.

Under the wavelength of green light at **302**, one sees the absorption of magenta dye as well as any surface defects. Under the wavelength of red light at **304**, one sees the absorption of cyan dye and surface defects. Under the wavelength of infrared light at **306**, an interesting thing happens; namely, all the dyes pass the infrared light and the image functionally disappears, so that under infrared light one sees a blank piece of film in addition to the surface defects. By dividing the measured red brightness by the measured infrared brightness, one can calculate what the measured red brightness would have been with no surface defects. After repeating this prior art process for all pixels in all primary colors, the surface defects can be erased from the image.

Returning to FIG. **2**, an infrared selective filter **250** is added to filter wheel **226** and used in conjunction with digital imaging device **208** to provide a fourth color memory, or channel, array **252** consisting of individual